

1 **Extreme decay of meteoric beryllium-10 as a proxy for persistent aridity:**

2 **Supplementary Document**

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Supplementary Table S1: Erosion rates used to estimate Paleolake Friis sediment age			
Reference	Material	Min-Max E (m My⁻¹)	Min-Max [¹⁰Be]_{initial} (atoms g⁻¹ x 10⁷)*
36	Sandstone boulder	0.32-1.31	1.65-6.77
37	Sandstone, granite boulders	0.133-1.02	2.12-16.28
38	Regolith	2.1	1.03
39	Regolith	0.19-2.6	0.83-11.40
18	Diamicton, sandstone	0.1-0.33	6.56-21.66
Overall range		0.1-2.6	0.83-22.0
Predicted age range (My)[†]		11.0-17.5	

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42 *Calculated using Eq. 1 and parameters as defined in text.

43 [†]Calculated using Eq. 2

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Supplementary Table S2: Concentration ranges of meteoric ^{10}Be adhered to lake sediments worldwide

Location	Sample type	Minimum [^{10}Be] (atoms g ⁻¹)	Maximum [^{10}Be] (atoms g ⁻¹)	Reference
Lake Lisan (Dead Sea), Negev Desert, Israel	Bulk lake bottom sediment	$0.78\pm0.03 \times 10^8$	$1.64\pm0.07 \times 10^8$	40
Lake Lehmilampi, Finland	Cored lake bottom sediment	2.1×10^8	1.76×10^9	41
Anderson Pond, Tennessee, USA	Cored lake bottom sediment	$2.16\pm0.13 \times 10^9$	$2.90\pm0.13 \times 10^9$	42
Lake Baikal, Russia	Cored lake bottom sediment	$5.07\pm0.39 \times 10^8$	$1.13\pm0.05 \times 10^9$	43
Lake Baikal, Russia	Cored lake bottom sediment	0.5×10^9	1.5×10^9	44
Lake Mega-Chad, North Africa	Paleolacustrine sediments	$2.38\pm0.25 \times 10^6$	$8.59\pm0.35 \times 10^7$	17
Hillpiece Bog, Tristan da Cunha	Lacustrine sediments	$7.02\pm0.379 \times 10^8$	$1.75\pm0.98 \times 10^9$	45
Union Lake, NJ. USA	Bulk lake bottom sediment	$1.20\pm0.60 \times 10^7$	$2.60\pm0.30 \times 10^{10}$	46
Lake Keilambete, Australia	Bulk lake bottom sediment	0.76×10^9	2.31×10^9	47
Lake Windermere, England	Bulk lake bottom sediment	1.11×10^9	1.6×10^9	47
Lake Zurich, Switzerland	Sediment trap sediments	$4.96\pm0.32 \times 10^7$	$2.54\pm0.20 \times 10^8$	48
Mono Lake, CA, USA	Bulk lake bottom sediment	0.7×10^8	4.1×10^8	49
Overall average[†] (atoms g⁻¹)		2.38×10^6	2.90×10^9	
[^{10}Be]_{initial estimates at Friis Hills}		8.3×10^6	2.2×10^8	

45 * Measurements initially reported in dpm kg⁻¹. Converted to atoms g⁻¹ using the following:
46 dpm (decays per minute) = A (radioactive activity) and A=λN, where N=atoms of ^{10}Be and
47 λ=5.0x10⁻⁷ y⁻¹.

48 [†] Not all values are published with associated error. As such, overall minimum and maximum
49 [^{10}Be] are calculated without reported error. Where an external age estimator was provided, the
50 effect of decay correction was calculated. Maximum decay corrected concentrations differ < 3%
51 from non-corrected values, and are not included in the overall average.

Supplementary References

36. Nishiizumi, K., Kohl, C. P., Arnold, J. R., Klein, J., & Middleton, R. Cosmic ray produced ^{10}Be and ^{26}Al in Antarctic rocks: Exposure and erosion history. *Earth Planet. Sc. Lett.* **104**, 440–454 (1991).

37. Summerfield, M.A., et al. Long-term rates of denudation in the Dry Valleys, Transantarctic Mountains, southern Victoria Land, Antarctica based on in-situ-produced cosmogenic ^{21}Ne . *Geomorphology* **27**, 113-129 (1999).

38. Putkonen, J., Balco, G., & Morgan, D. Slow regolith degradation without creep determined by cosmogenic nuclide measurements in Arena Valley, Antarctica. *Quat. Res.* **69**, 242-249 (2008).

39. Morgan, D., Putkonen, J., Balco, G., & Stone, J. Quantifying regolith erosion rates with cosmogenic nuclides ^{10}Be and ^{26}Al in the McMurdo Dry Valleys, Antarctica. *J. Geophys. Res.* **115**, F0307 (2010).

40. Belmaker, R., Lazar, B., Tepelyakov, N., Stein, M., & Beer, J., ^{10}Be in Lake Lisan sediments-A proxy for production or climate? *Earth Planet. Sc. Lett.* **269**, 448-457 (2008).

41. Berggren, A.-M., Aldahan, A., Possnert, G., Haltia-Hovi, E., & Saarinen, T. Linking ice sheet and lake sediment archives of ^{10}Be , 1468-1980 CE. *Nucl. Instrum. Meth. B* **294**, 524-529 (2013).

42. Brown, T.A., Nelson, D.E., Southon, J.R., & Vogel, J.S. ^{10}Be production rate variations as recorded in a mid-latitude lake sediment. *Nucl. Instrum. Meth. B* **29**, 232-237 (1987).

43. Horiuchi, K., et al. Last-glacial to post-glacial ^{10}Be fluctuations in a sediment core from the Academician Ridge, Lake Baikal. *Geophys. Res. Lett.* **26**, 1047-1050 (1999).

- 76 44. Horiuchi, K., et al. Climate-induced fluctuations of ^{10}Be concentration in Lake Baikal
77 sediments. *Nucl. Instrum. Meth. B* **172**, 562-567 (2000).
- 78 45. Ljung, K., Björck, S., Muscheler, R., Beer, J., & Kubik, P. W. Variable ^{10}Be fluxes in lacustrine
79 sediments from Tristan da Cunha, South Atlantic: a solar record? *Quat. Sci. Rev.* **26**, 829-835
80 (2007).
- 81 46. Lundberg, L., et al. ^{10}Be and Be in the Maurice River-Union lake system of southern
82 New Jersey. *J. Geophys. Res.* **88**, 4498-4504 (1983).
- 83 47. Raisbeck, G.M., et al. ^{10}Be in the environment: some recent results and their applications.
84 *Proc. Syrup. Accel. Mass Spectrom. Argonne, III: Argonne Natl. Lab.*, 458 (1981).
- 85 48. Schuler, C., et al. A multitracer study of radionuclides in Lake Zurich, Switzerland 1.
86 Comparison of atmospheric and sedimentary fluxes of ^7Be , ^{10}Be , ^{210}Pb , ^{210}Po , and ^{137}Cs .
87 *J. Geophys. Res.* **96**, 17051-17065 (1991).
- 88 49. Ticich, T., Lundberg, L., Pal, D.K., Smith, C.M., & Herzog, G.F. ^{10}Be contents of Mono
89 Lake sediments: search for enhancement during a geomagnetic excursion. *Geophys. J.*
90 *Int.* **87**, 487-492 (1986).